FMRI Signal Origin Study of Motor Task Activation in a Single Run Using MT-Interleaved EPI

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INTRODUCTION

The transfer of magnetization (MT) between highly mobile water protons and relatively immobile protons in macromolecules has been shown to affect functional MRI (FMRI) signal[1], as well as enhancing image contrast[2]. In this study, we describe a pulse sequence that allows collection of signals in task and resting states, both with and without MT weighting, within a single run. Results from motor cortex activation with a finger tapping paradigm are presented.

METHODS

An MT-interleaved EPI pulse sequence was developed based on the MT-prepared EPI sequence described previously[1]. It enables switching on and off of the MT preparation pulses during repeated image acquisition, allowing collection of image time series during different MT states and different functional states, in an interleaved fashion, within a single run of the pulse sequence.

All experiments were performed on a 1.5 Tesla Signa whole body scanner (GE Medical Systems, Waukesha, WI) using a three-axis torque-balanced local gradient coil with an end-capped transmit-receive RF coil set (Medical Advances, Milwaukee, WI). The imaging parameters used were: FOV = 24 cm, slice thickness 3 mm, image matrix 64 × 64, TE = 40 ms, TR = 250 ms, flip angle = 34°. A two-cycle sinc pulse was applied 1000 Hz off-resonance for MT pre-saturation, with an amplitude of 1.46×10^{-5} Tesla and a bandwidth of 400 Hz. The calculated SAR was below the limit specified by the FDA for human studies.

Motor cortex activation from bilateral finger tapping was studied in healthy volunteers. Two continuous on/off MT cycles were defined in the experiment. During each period, one cycle of on/off finger tapping was performed. Image time series were collected from an axial slice through the primary motor cortex. During post processing, data from the first 5 seconds after each switching of the MT weighting were excluded from the average, to ensure establishment of equilibrium. Activation maps were generated, at both zero and high MT-weighting, by calculating the percentage signal change between task and rest states.

RESULTS

A typical signal time series of an activated pixel is shown in Fig 1. The small increase due to functional activation is superimposed on the larger MT-related signal decrease. A scatter plot of the change in activation level between high and zero MT-weighting among all activated pixels is shown in Fig 2.

DISCUSSION

The ability of collecting images during different functional and MT states within a single run eliminates the need to stop the experiment between runs, and therefore minimizes systematic error introduced into FMRI studies such as subject motion. It allows accurate localization of the signals to corresponding pixels. With this method, pixel-wise comparison and analysis of the FMRI signal origin is more reliable based on the three-compartment model[3].

MT-weighting separated the activated pixels into two distinct groups. One group (A) has large relative signal change with activation, which corresponds to pixels occupied mostly by large vessels. In this pixel group, MT effect decreases the functional signal intensity by saturating the signal from tissue surrounding the vessels. Another group of pixels (B) cluster at less than 1% on the activation scale. They are likely pixels where the sizes of the vessels are at the capillary level. In this group of pixels, MT preparation enhances the activation by saturating the non-active tissue and reducing partial volume averaging. We conclude that MT preparation offers a way to further localize the functional BOLD response to parenchymal brain tissue.

REFERENCES

1. Zhang, Cox and Hyde, *Magn Reson Med*, **38**, 187, 1997
2. Wolff and Balaban, *Magn Reson Med*, **10**:135, 1989
3. Ogawa, Menon and Uğurbil, *Magn Reson Biol Med Q*, **2(1)**:43, 1995

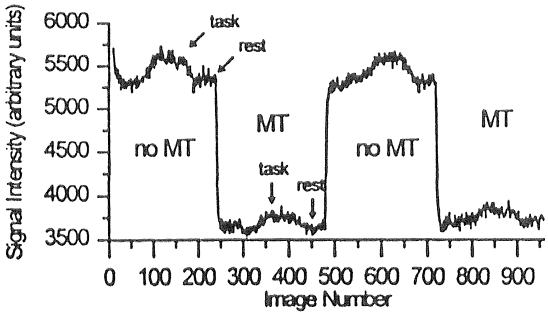

Fig. 1. Signal time series from a representative pixel in the motor cortex.

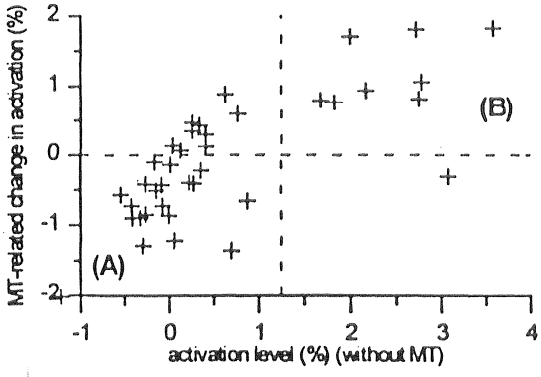

Fig. 2. MT-induced change of activation vs. strength of activation in activated pixels.

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